

LDCM Operational Land Imager and Thermal Infrared Sensor Performance

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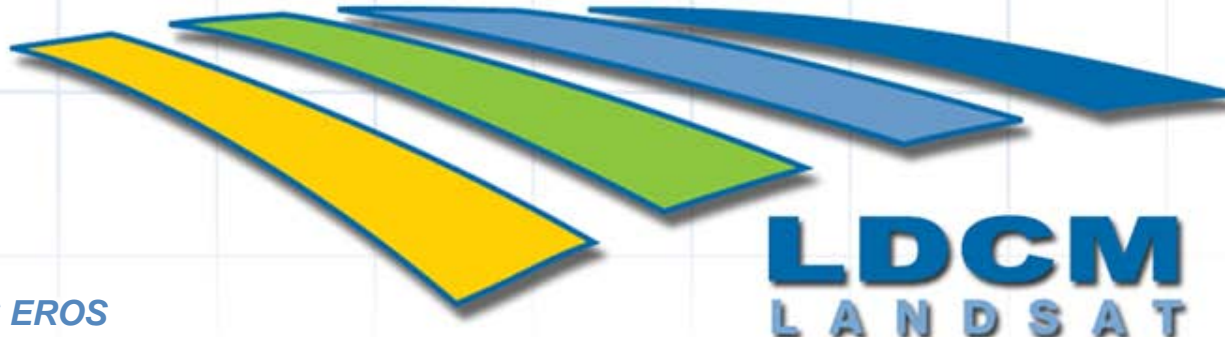
Representing NASA/USGS/BATC Instrument and Calibration Teams

August 23, 2011

**SPIE
Earth Observing
Systems XVI**

NASA GSFC / USGS EROS

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data continuity mission

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 - Julia Barsi /SSAI
 - Lawrence Ong /SSAI
 - Robert Barnes /SAIC
 - Matt Montanaro /Sigma Space
- Phil Dabney (Instrument Scientist)
- Jeff Pedelty (BATC on-site rep)

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- Ron Hayes/SGT (Lead)
- Ron Morfitt /SGT (Technical Lead)
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 - Pat Scaramuzza /SGT
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➤ BATC OLI CALIBRATION/SYSTEMS

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- Brent Canova (Lead)
 - Geir Kvaran
 - Kenton Lee
 - Eric Donley
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➤ GSFC TIRS CALIBRATION

- Dennis Reuter (instrument scientist)
- Kurtis Thome (Lead)
 - Brian Wenny
 - Allan Lunsford
 - Matt Montanaro
 - Tesfaye Zelalem
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- Dennis Helder (SDSU)
- John Schott (RIT)
 - Orlando/Nina Raqueno
 - Mike Gartley
 - Aaron Gerace

Landsat and LDCM Spectral and Spatial Requirements

Landsat-5/7 TM/ETM+ Bands (μm)			LDCM Band Requirements (μm)		
			30 m Coastal/Aerosol	0.433 - 0.453	Band 1
Band 1	30 m Blue	0.450 - 0.515	30 m Blue	0.450 - 0.515	Band 2
Band 2	30 m Green	0.525 - 0.605	30 m Green	0.525 - 0.600	Band 3
Band 3	30 m Red	0.630 - 0.690	30 m Red	0.630 - 0.680	Band 4
Band 4	30 m Near-IR	0.775 - 0.900	30 m Near-IR	0.845 - 0.885	Band 5
Band 5	30 m SWIR-1	1.550 - 1.750	30 m SWIR-1	1.560 - 1.660	Band 6
Band 6	60/120m* LWIR	10.40 - 12.50	120 m LWIR-1	10.30 - 11.30	Band 10
			120 m LWIR-2	11.50 - 12.50	Band 11
Band 7	30 m SWIR-2	2.090 - 2.350	30 m SWIR-2	2.100 - 2.300	Band 7
Band 8**	15 m Pan	0.520 - 0.900	15 m Pan	0.500 - 0.680	Band 8
			30 m Cirrus	1.360 - 1.390	Band 9

OLI

TIRS

OLI

Operational Land Imager (OLI)

■ Key instrument requirements

- Cross-track FOV 185 km
- S/C altitude 705 km
- Geodetic accuracy*
 - ❖ Absolute 65 m
 - ❖ Relative 25 m
- Geometric accuracy**
 - ❖ Absolute 12 m

Band Name	CW (nm)	Bandwidth (nm)	GSD (m)	SNR
Coastal/Aerosol	443	20	30	130
Blue	482	65	30	130
Green	562	75	30	100
Red	655	50	30	90
NIR	865	40	30	90
SWIR 1	1610	100	30	100
SWIR 2	2200	200	30	100
PAN	590	180	15	80
Cirrus	1375	30	30	50



Visible/NIR
 SWIR

*No terrain compensation

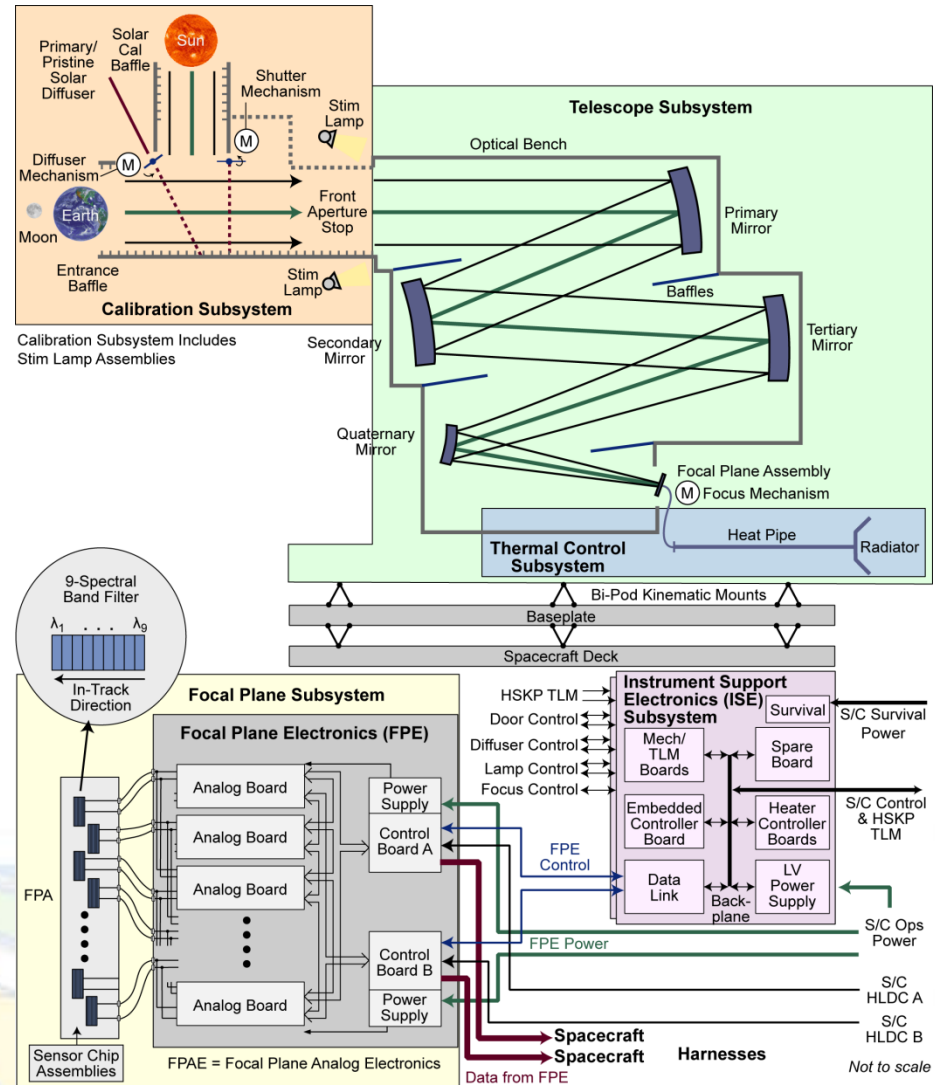
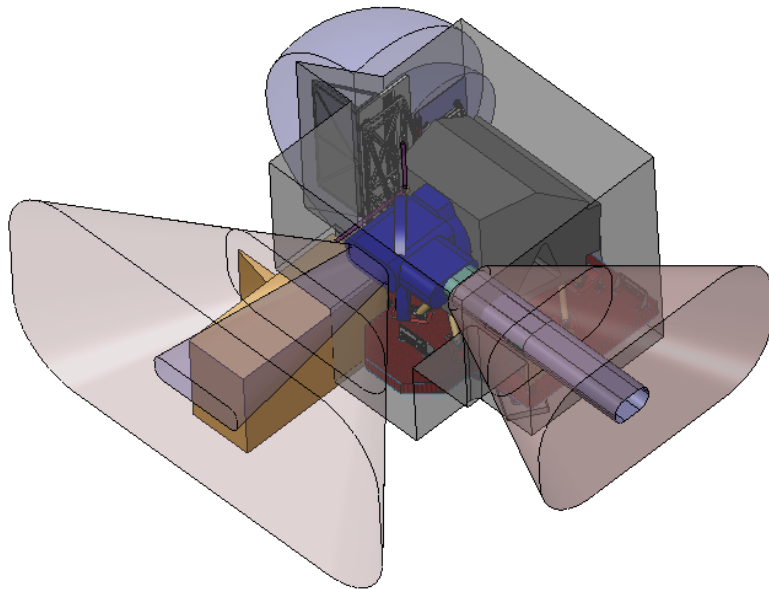
**w/ terrain compensation

Instrument
Complete

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Operational Land Imager (OLI)

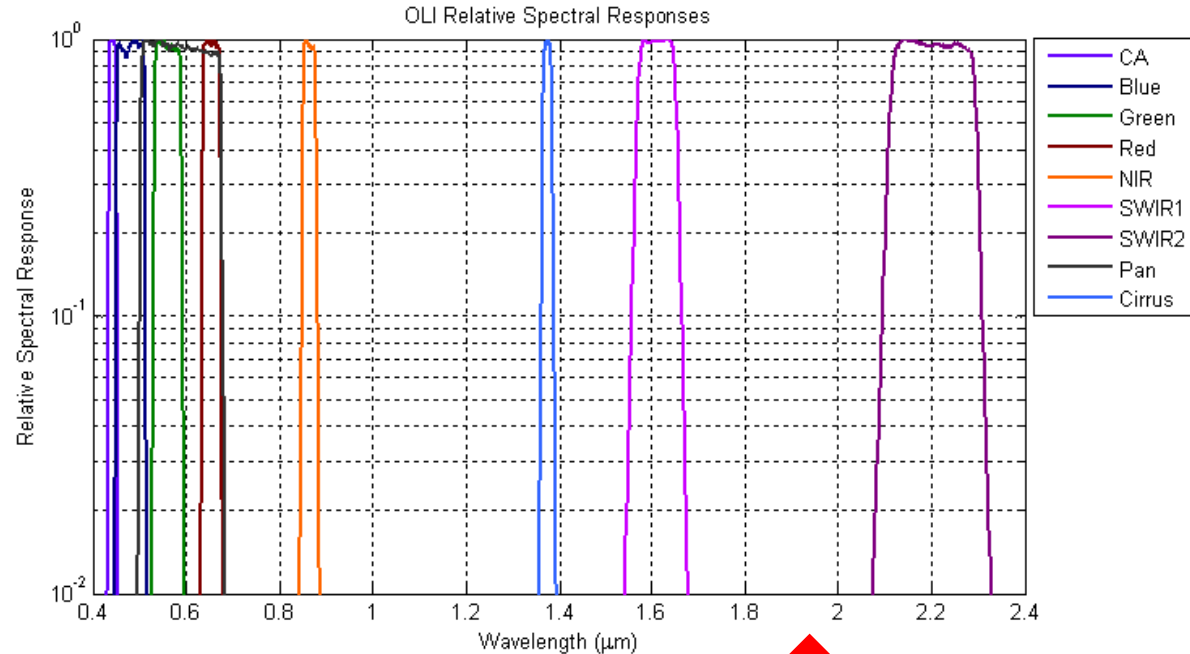
- Pushbroom VIS/SWIR sensor
- Four-mirror telescope with front aperture stop
- FPA consisting of 14 sensor chip assemblies, passively cooled
- On-board calibration with both lamps and full aperture diffusers



OLI Spectral and Polarization Performance

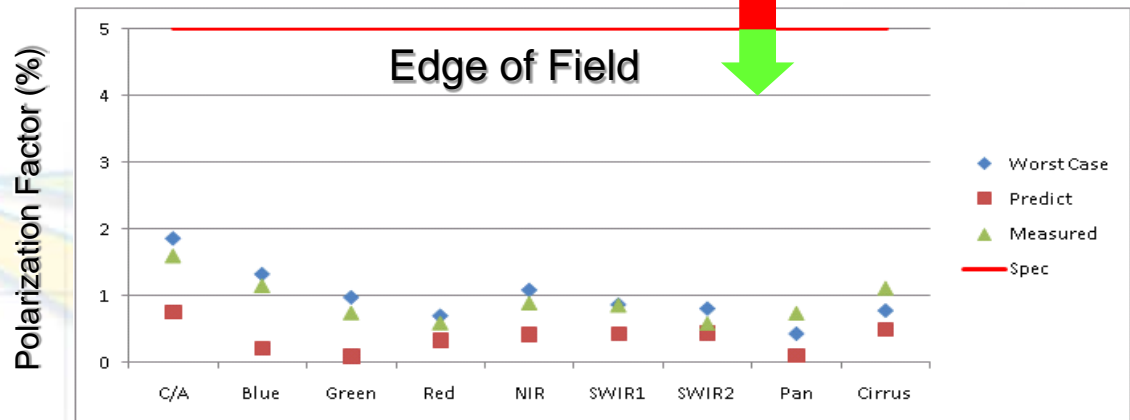
➤ Spectral Performance

- Measured at instrument level for sampling of detectors from each focal plane module
 - Meets all requirements
- Out-of-Band Response measured at focal plane module level for all detectors
 - typically below 10^{-4}



➤ Polarization Sensitivity

- Measured at instrument level
- Below 2%



OLI Radiometric Performance

➤ SNR

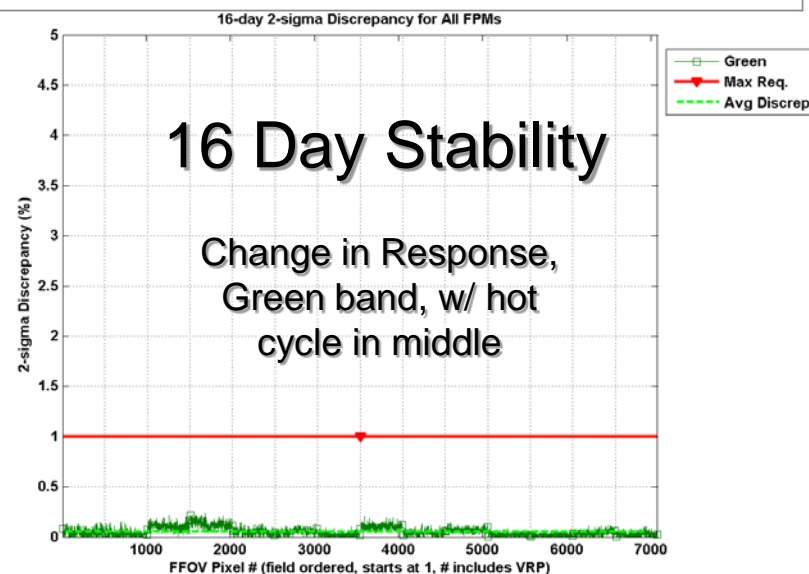
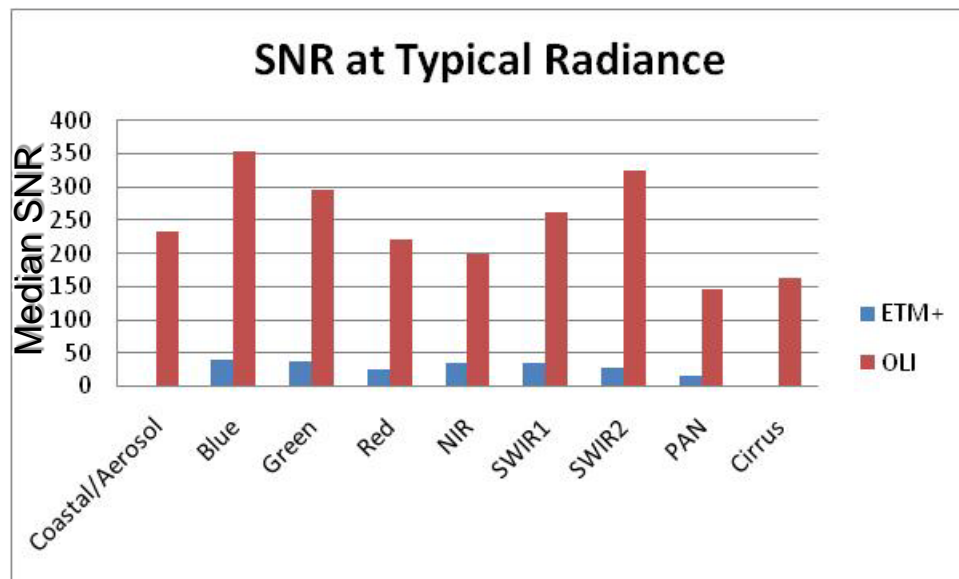
- SNR significantly exceeds requirements and heritage

➤ Calibration

- Absolute uncertainty ~4%
 - Extensive round robin for validation
 - Transfer-to-Orbit uncertainties included
- Stability over 60 seconds (2 standard scenes)
 - $<0.02\%$ 2σ
- Stability over 16 days (time between Solar Diffuser Cals)
 - $<0.54\%$ 2σ for all but Cirrus Band which is $<1.19\%$

➤ Uniformity

- Typically better than 0.5%
 - A few detectors and FPM boundaries may exceed this



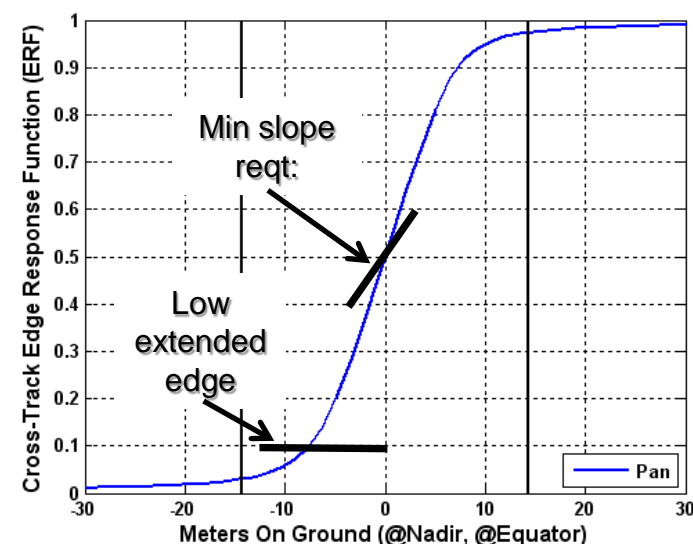
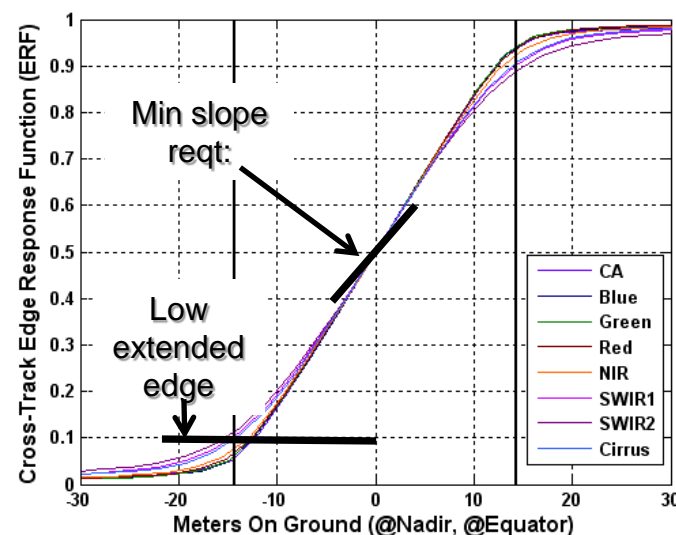
OLI Spatial Performance

➤ Spatial Performance

- Want sharp edges for change detection
- Measured spatial response has:
 - Steep slope (exceeding reqts)
 - Low extended edge (good half edge extent)
 - No ripple/overshoot

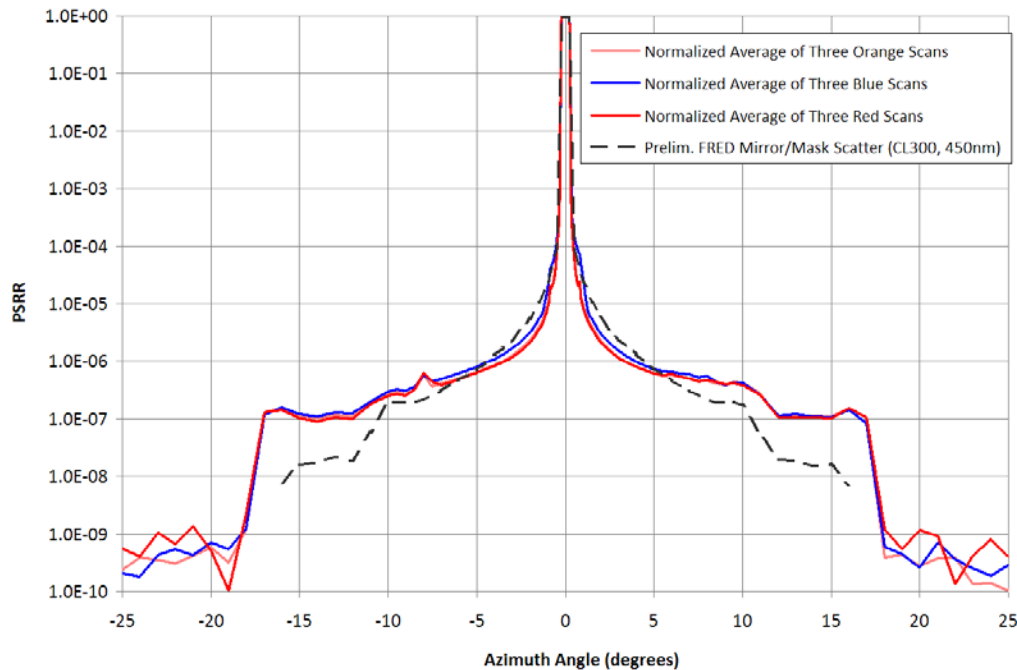
➤ Geolocation

- Want good pointing knowledge, again for change detection
- Performance depends on both instrument and spacecraft; final measurements made during initial on-orbit checkout
- Pre-launch instrument measurements mapped line of sight of all detectors to reference pixel/boresight to $\sim 1/10^{\text{th}}$ of a pixel
- On target to have absolute geometric accuracy of $< 1/2$ pixel



OLI Stray Light

Comparison of Azimuth Scans for Three Filters



- Meets requirements
- Consistent with modeled performance



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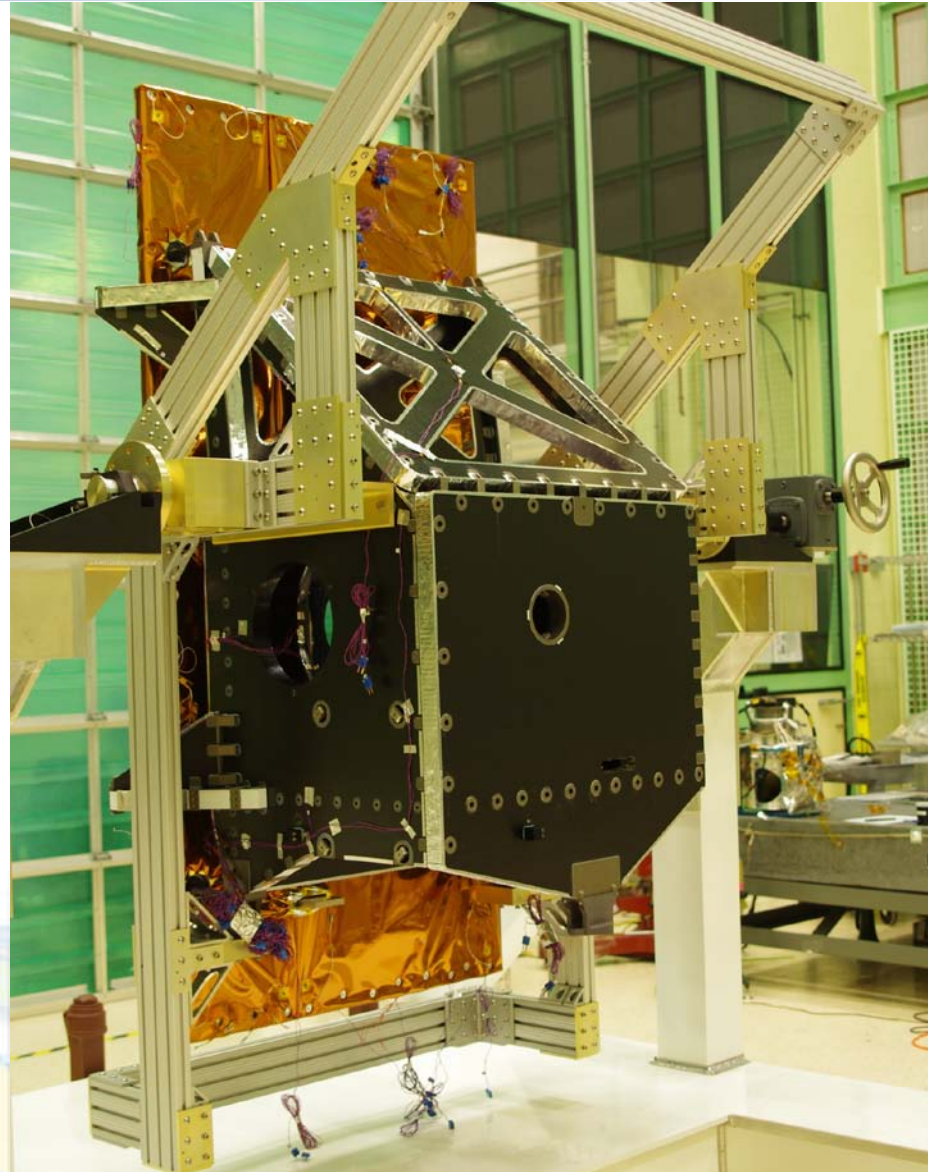
Stray Light Ninjas

Thermal Infrared Sensor (TIRS)

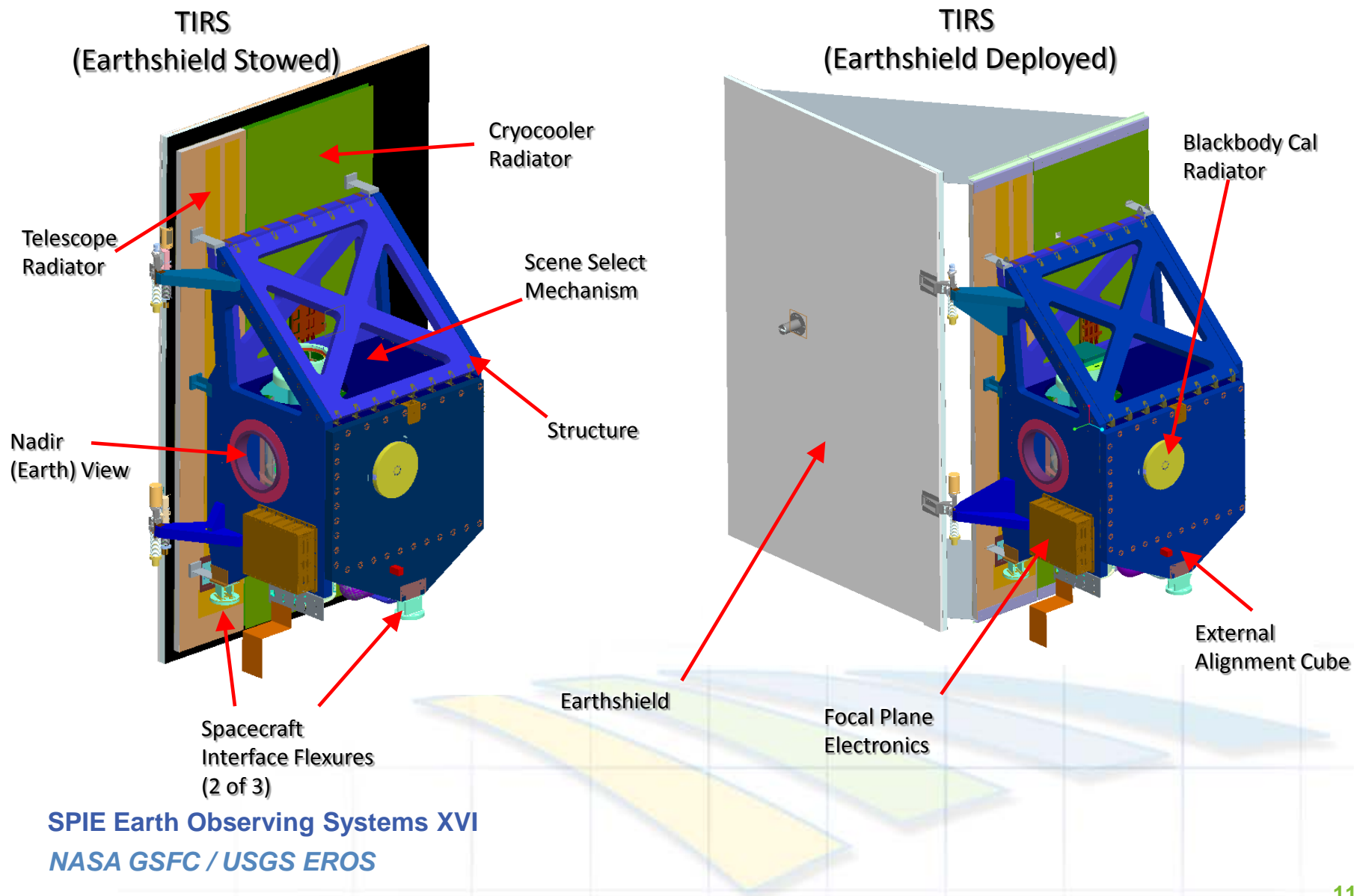
- Quantum well infrared photodetector (QWIP) focal plane array (built at GSFC), at 43K
- 2-Channel IR spectral imager
 - 10.8 μm and 12 μm
 - Split window atmospheric correction
- Two full aperture calibration sources
 - Onboard blackbody
 - Space view
 - Calibration every 34 minutes
- Scene select mirror selects between calibration sources, nadir
- 185 km ground swath (15° FOV)
- 100 meter resolution
- TIRS delivery December 2011
- 3.25 year life, Class C instrument
- TVAC testing (full instrument) started

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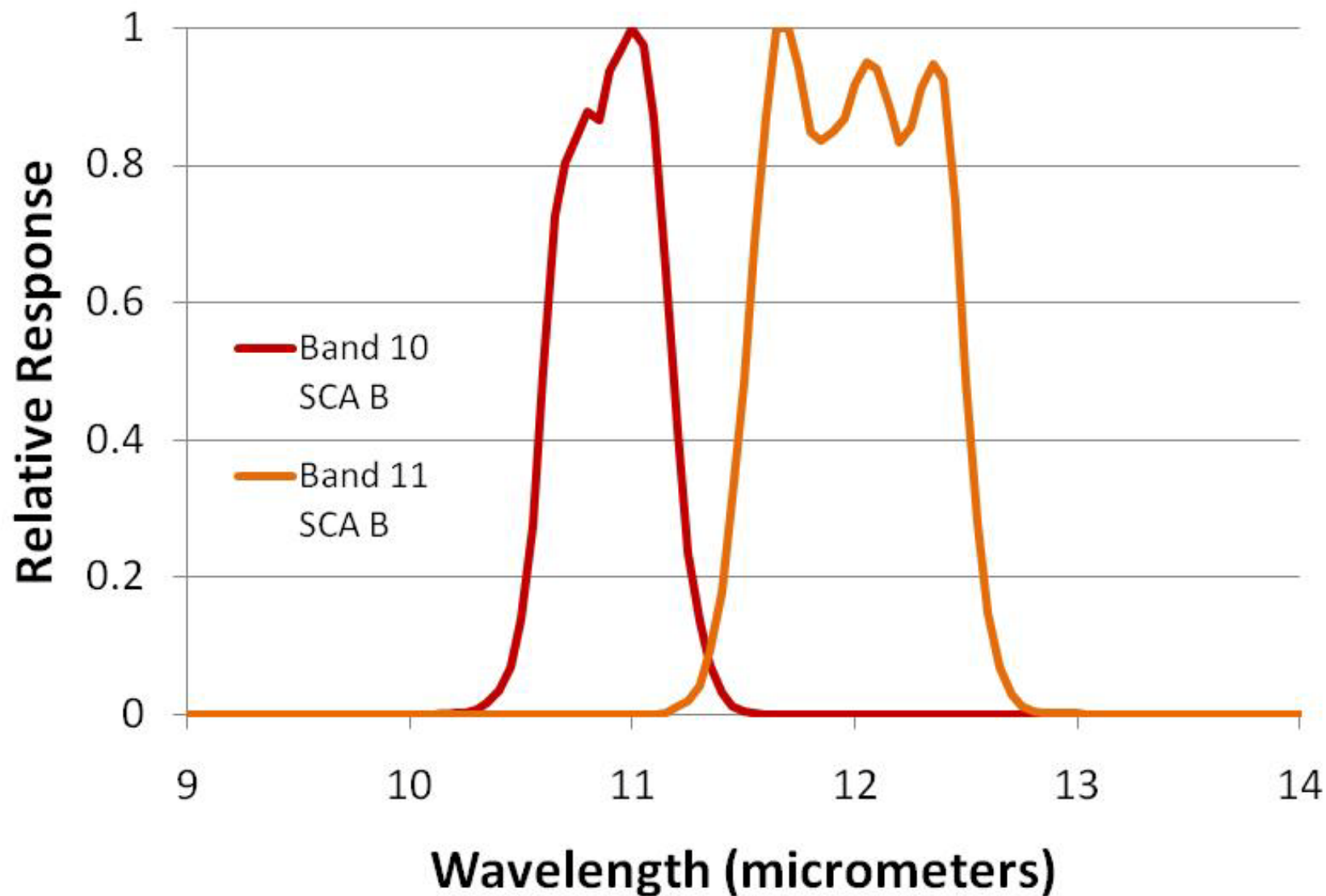


TIRS Overview



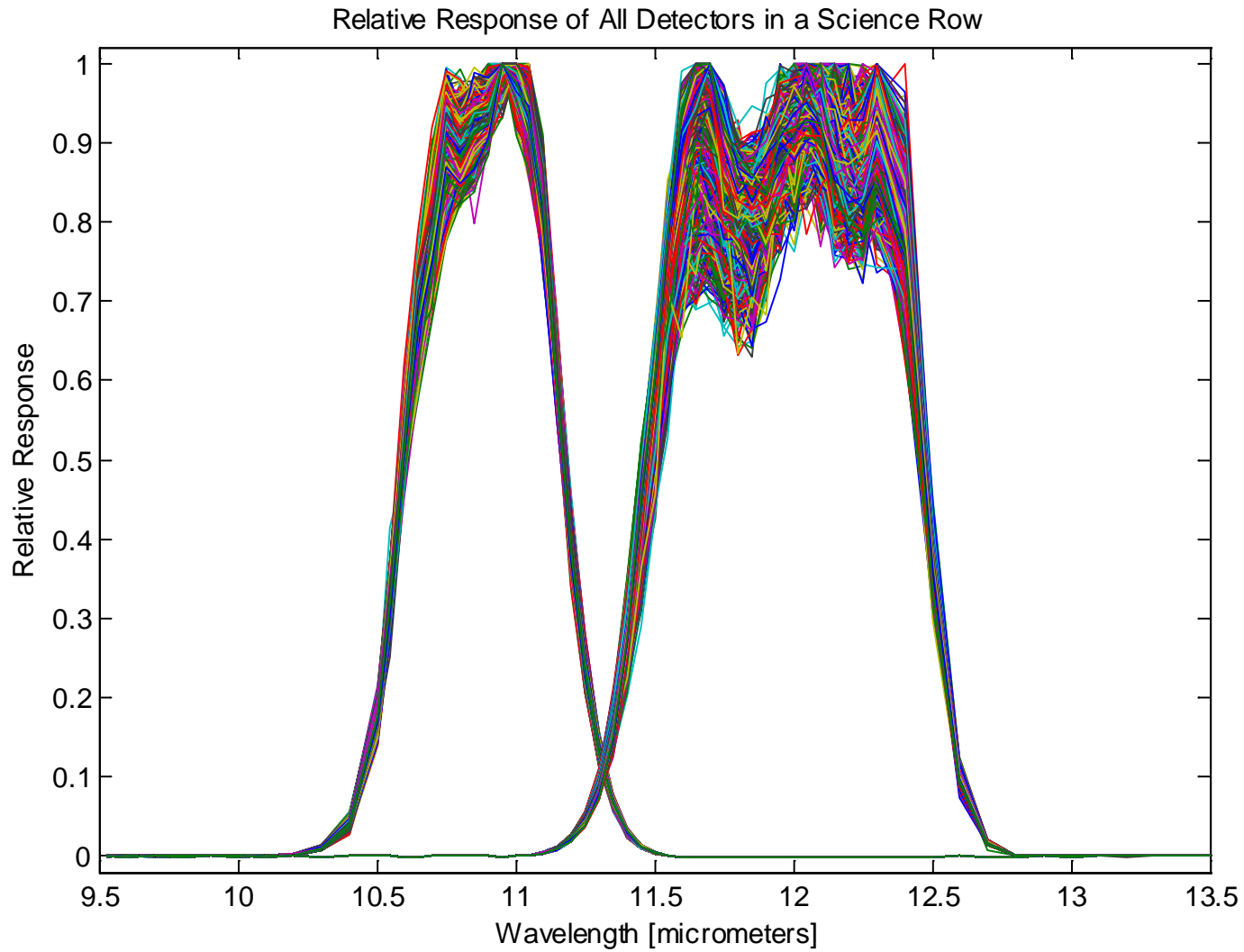
TIRS Relative Spectral Response

Average: based on component level measurements



TIRS Relative Spectral Responses

All Detectors – based on component measurements

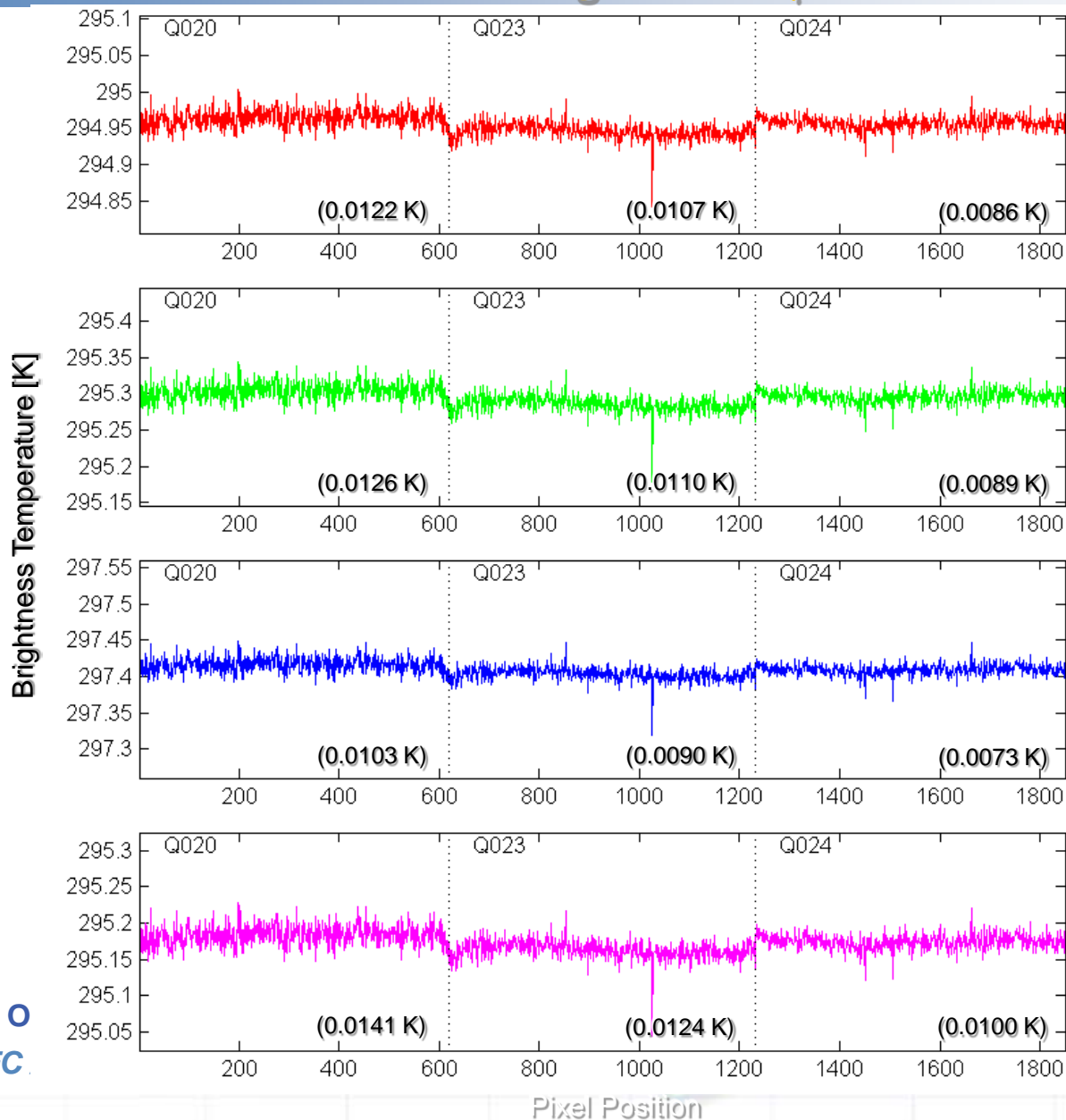


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Spectral Uniformity Impact

300K Surface Target : 10.8 μm band



Tropical

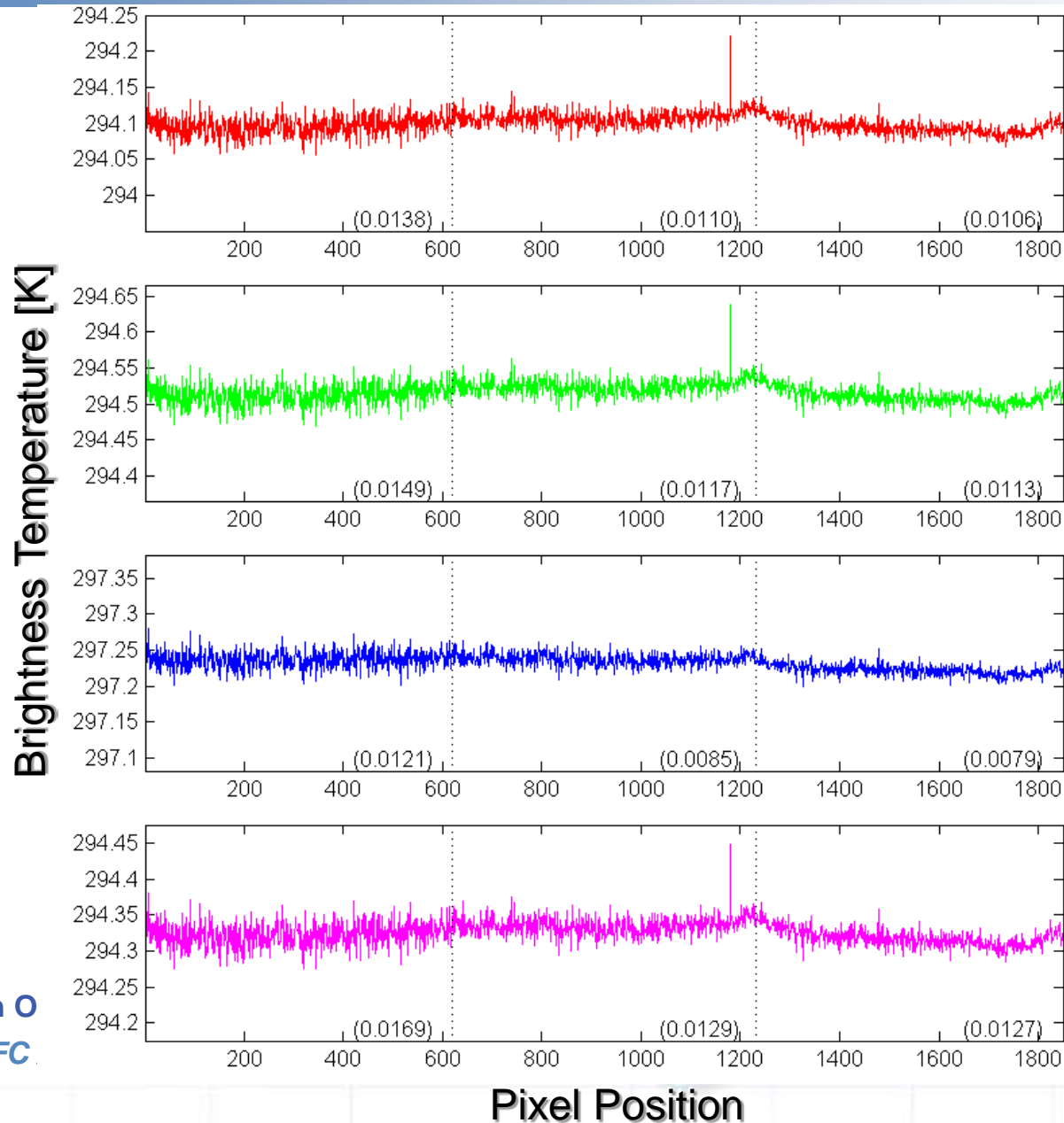
Mid-Latitude Summer

Mid-Latitude Winter

Sub-Arctic Summer

Spectral Uniformity Impact

300K Surface Target : 12.0 μm band



Tropical

**Mid-Latitude
Summer**

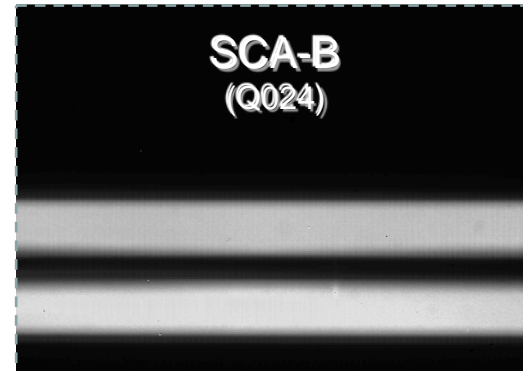
**Mid-Latitude
Winter**

**Sub-Arctic
Summer**

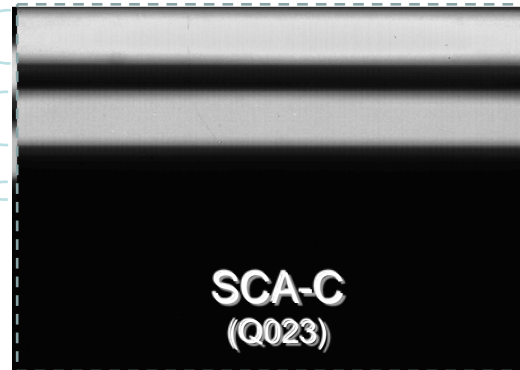
TIRS Calibration Images



Dark Band
10.8 um Band
12 um Band



~ 36 un-vignetted rows
~ 36 un-vignetted rows
~ 18 dark rows



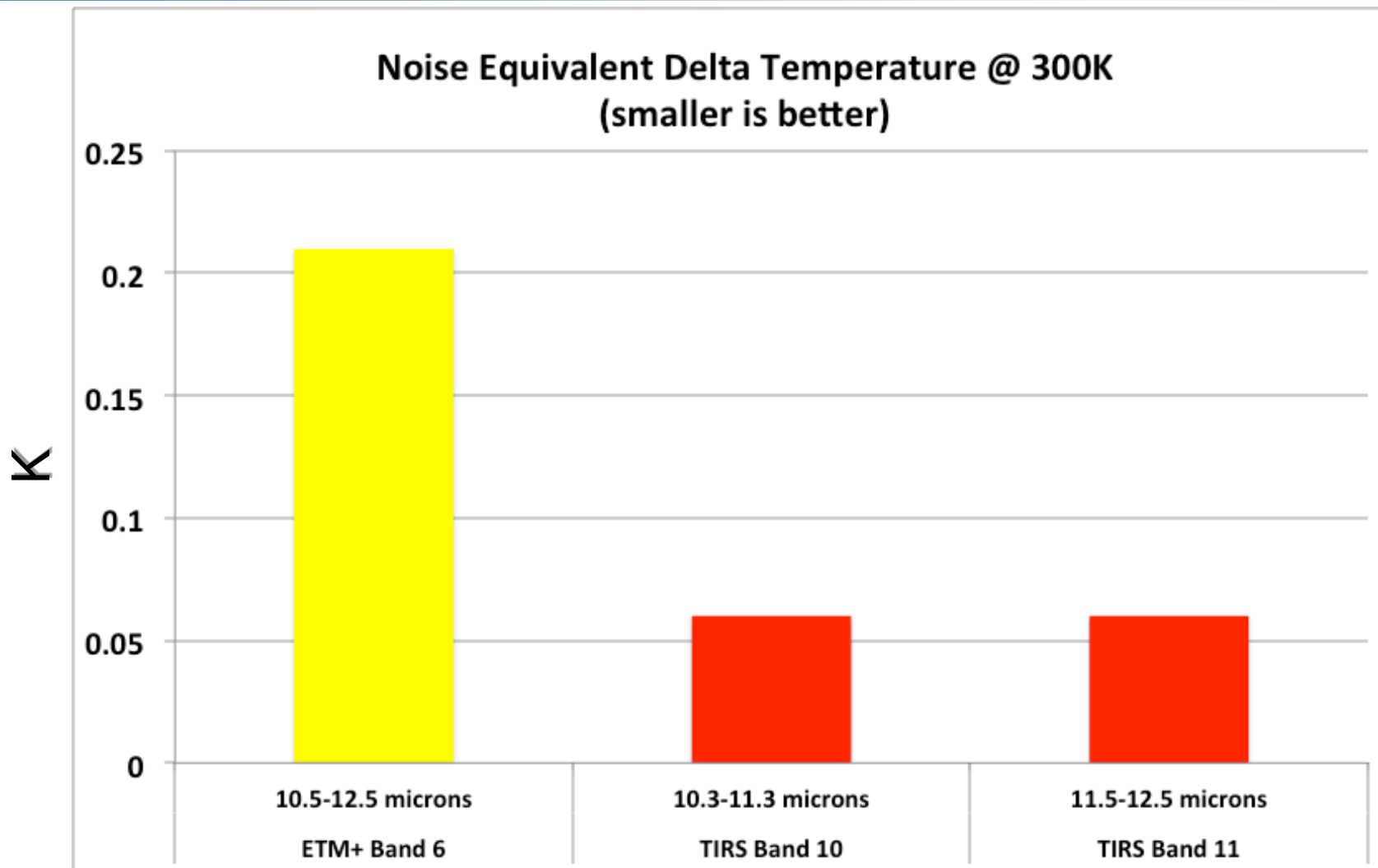
12 um Band
10.8 um Band
Dark Band

- SNR ~1,500 for 360 K source and ~1,000 for 300 K
- >3X more than required
- Consistent with shot-noise limited

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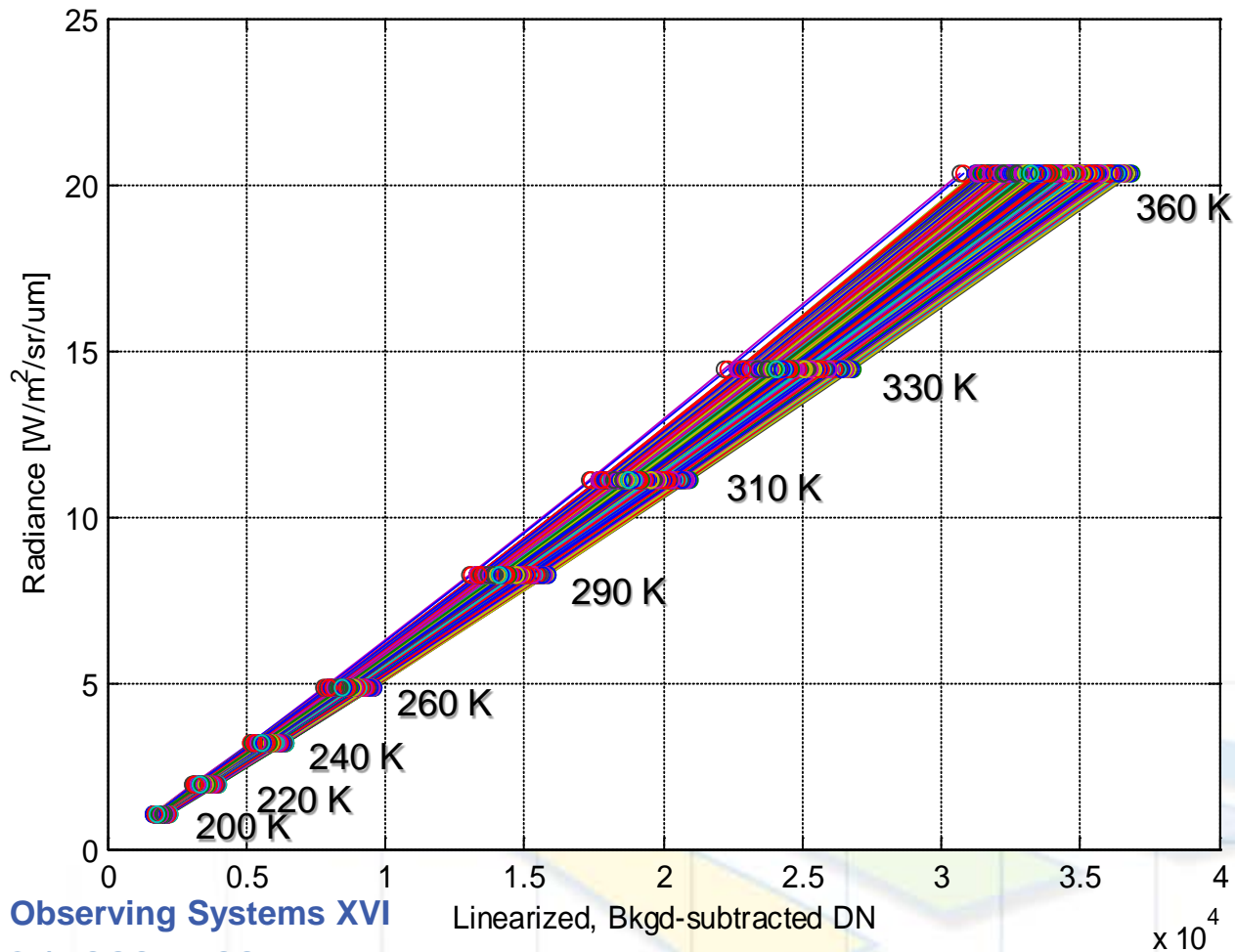
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TIRS Preliminary Radiometric Performance



Radiometric Responsivity Variation with 12.0 μm Band

Radiance vs. Linearized, Bkgd-subtracted DN for IRSM temperatures of:
[200 K, 220 K, 240 K, 260 K, 290 K, 310 K, 330 K, 360 K]



Summary

➤ OLI

- Instrument complete – currently investigating heater controller anomaly
- SNR performance substantially exceeds requirements
- Absolute calibration meets requirements
- Relative (detector to detector) calibration meets requirements with possible exception of a few FPM boundaries and a few detectors
- Spatial response meets requirements

➤ TIRS

- Instrument now in primary thermal vacuum performance testing
- SNR performance expected to substantially exceed requirements
- Absolute calibration expected to exceed requirements
- Relative (detector-to-detector) calibration expected to meet requirements